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Abstract

Social and economic infrastructure are essential for economic development. However, over the last three decades, many infrastructure projects in developing countries have failed. These failures raise the question as to the role of governments in the provision, and longevity, of much needed infrastructure. In this paper, we seek to examine the significance of governments' residual ownership in determining the failure of infrastructure projects that started as Public-Private Partnerships (PPP). We utilise duration analysis to analyse 2,721 PPP projects across six regions globally and find that assigning the residual ownership of infrastructure projects to the government reduces the probability of project failure. It may be the case that assigning the risk of residual ownership to governments makes the project more affordable to end users. We also find that both project size and sector play an important role in determining the probability of project failure. These findings provide policy insights and highlights issues around the way infrastructure projects in developing countries are negotiated between the private sector and governments.

Keywords: Public-Private Partnerships; Residual ownership; Survival analysis; Infrastructure project failure; Development policy.

JEL codes: H54, H82, O21, O18.

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Abstract

Social and economic infrastructure are essential for economic development. However, over the last three decades, many infrastructure projects in developing countries have failed. These failures raise the question as to the role of governments in the provision, and longevity, of much needed infrastructure. In this paper, we seek to examine the significance of governments' residual ownership in determining the failure of infrastructure projects that started as Public-Private Partnerships (PPP). We utilise duration analysis to analyse 2,721 PPP projects across six regions globally and find that assigning the residual ownership of infrastructure projects to the government reduces the probability of project failure. It may be the case that assigning the risk of residual ownership to governments makes the project more affordable to end users. We also find that both project size and sector play an important role in determining the probability of project failure. These findings provide policy insights and highlights issues around the way infrastructure projects in developing countries are negotiated between the private sector and governments.

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1 Introduction

Building on seminal work, particularly Rosenstein-Rodan (1943) and Murphy *et al.* (1989), many in the development and policy community advocate a 'big push' to help low-income countries escape poverty (e.g., Sachs *et al.* 2004, Collier 2006). Although these calls propose a variety of policies, virtually all of them lay emphasis on the importance of good governance and infrastructure. Starting with the work of Aschauer (1989), as well as in policy debates (e.g., World Bank 1994, 2019), adequate supply of infrastructure by governments has long been viewed as indispensable for long-term and sustainable economic development, for job creation, poverty reduction and improved welfare, even in the short-term.

In light of increasing demand for infrastructure for economic development, coupled with the limited resources and skills to build, maintain, and repair these facilities, Public-Private Partnerships (PPPs) are increasingly being adopted by governments to deliver new infrastructure. Although the net contribution of PPPs is a controversial issue, there is sufficient evidence supporting its relevance in infrastructure development and related service delivery, particularly in developing countries facing significant infrastructure deficits. More specifically, the terms of engagement that come with PPPs are becoming increasingly important, both politically and economically. Ideally, to obtain infrastructure investments aimed at promoting economic development and for sustainable development, developing country governments need to secure investment terms that will not saddle the country with net negative benefits. This underscores the crucial role of government in this process of economic management.

The 2017 Global Infrastructure Outlook reports a \$15 trillion infrastructure investment gap i.e. between a projected \$79 trillion investment and the \$94 trillion required for adequate global infrastructure by 2040, 19% higher than would be delivered under current trends, with Africa and Asia accounting for \$6.3 trillion of this shortfall, and the biggest gaps being in Energy and Road Transport.[1] Efficiency gains associated with the PPP mode of procurement relative to traditional methods have been compared in some fairly recent literature (see Buso *et al.*, 2017; Byoun *et al.*, 2013).[2] However, Residual Value Risk (RVR) is also a critical concern if projects revert to the public sector, and developing countries cannot afford to have such risks added to their existing socio-economic problems.[3] Despite the need for infrastructure development, RVR becomes instrumental for whether the PPP investment will take place at all. This has not yet been thoroughly studied within the context of economic development, and is a gap this study aims to address. Many commentators focus on 'financing' for plugging the gap, in an overtaxed and over-borrowed world, but affordability is crucial.

Further, PPP failures can have important deleterious implications, particularly for developing countries since such failures often impair governments' ability to provide socio-economic infrastructure vital for economic growth (Röller and Waverman, 2001), poverty reduction, and also prevention of conflicts (Beall *et al.*, 2013). Intuitively, even the anticipation of failure could deter private investors from engaging in PPPs or, at best, lead to requirement of excessive premiums as a prerequisite, both of which are costly for the host country. The relevance of such failures should not be underestimated, and is a motivation for this study.

We analyze a sample of 2721 PPP projects implemented between 1986 and 2015, as reported by the World Bank. In our sample, the monetary value (number) of projects that failed was approximately US\$78 billion (253), while the monetary value (number) of successfully completed projects was around US\$60 billion (181). We define *project failure* as a deviation of the PPP

[1] See Global Infrastructure (GI) Outlook 2017 Report.

[2] In the traditional method of procurement, the government contracts the private sector for the delivery of public services through competitive tendering under several contracts including, design, construction and operation contracts. Meanwhile, PPP bundles investment, construction and service provision into a single long-term contract, thus bringing greater efficiency in the process (see Engel *et al.*, 2013).

[3] According to HM Treasury, 'Residual Value Risk' refers to the uncertainty as to what the residual value will prove to be at the expiry of the PPP project.

project outcome from its original conceptualisation by the partners. Against this background, and noting developing country governments' need for PPP infrastructure investment for economic growth and development, plus the deleterious costs of failure, this study aims to investigate and posit on a central question: How should PPP projects be structured to mitigate the risk of failure? The role of government is central here since, we argue, governments' role in residual ownership can impact project survival. We build on the *incomplete contracting* literature to derive a hypothesis linking the risk of PPP project failure to the ownership of residual facilities. We then test this hypothesis using our sample of PPP projects from 114 low- and middle-income countries across six regions around the world. In our analysis, residual facility ownership refers to the ownership of the residual facility of the PPP project at the expiry of the contract.

Intuitively, PPP ownership will incentivise the owner if *expected* residual value is positive (see Aghion and Holden, 2011). However, since residual value is unknown when entering into a PPP contract, RVR may be costed and incorporated *ex-ante* into the overall project cost. The net benefits of PPP projects, which have the average age of around 30 years (see Iossa and Martimort, 2015), are uncertain. Residual owner(s) are therefore exposed to RVR and, as is often the case, where the partners' investments are unverifiable, profit will be the likely motivation for the private partner. Therefore, transfer of residual ownership to the private partner could, *ceteris paribus*, lead to an increase in the required risk premium and hence, the project cost, making it less-affordable to the poor which is often cited as a catalyst for the failure of many PPP projects because long-term charges must be within the end-users' budget. However, such increased costs could be mitigated if ownership is conferred on the public sector, whose objectives should be public welfare, rather than profit maximization.[4] Within this context, we provide a novel finding that suggests that the survival of PPP projects, including development-enhancing infrastructure, can be greatly enhanced if they are structured to confer residual facility ownership to the public sector, rather than the private sector.

The remainder of this paper is organised as follows: Section 2 presents some relevant background theory and highlights some relevant evidence in the extant literature. Sections 3 describes the data and empirical methods employed, while Section 4 reports our empirical results and a discussion of the results. Section 5 concludes with a summary and some policy recommendations.

2 Theory and Evidence

Notwithstanding associated challenges, PPPs are considered by many governments and international institutions, such as the World Bank, as a preferable option to accelerate delivery of infrastructure and related services to spur infrastructure provision. Governments' re-election motives cannot also be ruled out. These underscore the relevance of PPP for practitioners, academics and policy-makers *vis-à-vis* economic development. To this end, data-driven research to uncover evidence on how the survival of PPP projects can be enhanced in relation to how projects are structured is crucial. Further, there is a need to link theories on residual ownership in PPP project arrangements with empirical outcomes.

2.1 PPPs: A brief overview

Although the World Bank Public Private Partnerships website provides a comprehensive detail, a brief overview is instructive.[5]

PPPs are typically classified as 'Greenfield' (collaboration between the public and private sector for the development of an entirely new facility) or 'Brownfield' (collaboration for the re-

[4]This could be one possible reason that although the UK government specified the conditions for residual ownership allocation, its preferred option, however, is an automatic transfer of the residual facilities to the public sector at the end of the contract (see Bennett and Iossa, 2006).

[5]See World Bank Public Private Partnerships website.

habilitation and/or expansion of an existing facility). Greenfield PPP projects are generally structured as build, operate and transfer (BOT), which confers residual ownership of the facility to the public sector, or build, operate and own (BOO), which allows the private partner to retain the residual facility.

- Build, Operate and Transfer (BOT) a these typically allow the private partner to develop a brand-new facility, operate and maintain the facility over a period agreed with the public partner (normally referred to as the concession period), and later transfer the facility to the public partner. The public partner has the obligation to purchase either the infrastructure created or the services emanating thereof during the concession period.

- Build, Operate and Own (BOO) – these allow the private partner to develop the facility, operate and maintain the facility and at the end of the concession period, retains the facility. In this case, the residual ownership of the facility goes to the private partner.

Since PPP projects are usually financed on a non-recourse basis, the liabilities of the partners are limited to the facility created. To implement a PPP project, after all feasibilities and recruitment of the private partner has been concluded, the partners normally enter into a purchase agreement. Specifically, a special purpose vehicle (SPV) is formed, typically by the private partner (referred to as the sponsor) to source debt financing and issue out contracts and, in providing financing to the SPV, the creditors normally ask for a direct agreement to be signed with the public partner/Government, giving them the right to step-in and take ownership/control of the facility in the event of payment default.

In the case of Brownfield projects, the private partner is normally required to rehabilitate and operate the facility and later transfer it to the public partner i.e., such arrangements are referred to as rehabilitate, operate and transfer (ROT). In other cases, the private partner is expected to create a new facility in addition to the existing facility i.e., build, rehabilitate, operate and transfer (BROT). For Brownfield projects, it is hardly the case that the residual facility is retained by the private partner.[6] Given the aims of this study i.e., analysing residual ownership and whether it matters for project survival, our focus is on 'Greenfield projects'.

In terms of how the output price is typically set for typical PPP projects, the process begins at the negotiations stage. At this stage, the private partner, in collaboration with the public partner, develops a financial model that incorporates the costs to the parties, debt and equity, as well as the debt and dividend payments. These costs are then spread over the concession period to determine the tariff or per unit price of the output to be paid by the public partner i.e., the buyer/off-taker's tariff. For example, the public partner could be asked to pay a tariff of 10 US cents/kWh in a power project. The public partner in turn computes the cost of distributing the power to the end-user and develops an end-user tariff, say 11 US cents/kWh.

Clearly, bargaining power is crucial in allocating risks between parties in PPP transactions, as well as in the determination of the output tariff (price). Several factors come into play in determining a party's bargaining power in PPPs. These include previous experience, time taken to conclude negotiations and the options available to the party. As noted by Svejnar (1986), a party with no bargaining power is more likely to receive an adverse pay-off corresponding to the disagreement outcome. In PPPs, the key role of government is underscored by the fact that PPP output tariffs are normally higher for countries that lack experience in PPP negotiations, have serious infrastructure deficits, weak regulatory frameworks, poor governance structures and significant fiscal challenges.

[6] See the World Bank Private Participation Infrastructure database 'Glossary of Terms' section for additional information.

2.2 Infrastructure and economic growth

Some theoretical justifications for policies promoting infrastructure investment are found in the economic growth literature. Typically, the generic framework follows an aggregate production function, where real aggregate output (Q) is a function of a range of variables.[7] In brief:

$$Q = A(\theta, Inf).F(NonInf, L, B(Inf)) \tag{1}$$

where *NonInf* is the non-infrastructure aggregate capital stock, *Inf* the infrastructure capital stock, L is the aggregate hours worked by the labour force. A(.) is a standard productivity term, which incorporates generic efficiency-enhancing externalities, represented by θ, which can be interpreted as the 'indirect' effect of infrastructure. The theory also notes that *Inf* enters the production function F(.) through a function B(*Inf*) which allows Equation 1 to accommodate situations where infrastructure is considered simply as an additional factor of production i.e. B(*Inf*)=Inf, as is often done in the macro literature (see for example, Romp and de Haan, 2005). The formulation also addresses the assumption that the stock of infrastructure has pure public good attributes and produces services in a non-rival and non-excludable way. B(*Inf*) may be termed as the 'direct' effect of *Inf* on Q.

In terms of direct channels, infrastructure promotes economic growth by providing access to certain remote areas, roads or bridges that facilitate private investment required for growth. Entrepreneurship, for example, is likely to be enhanced through access to certain services such as electricity and/or telecommunications investments in critical parts of infrastructure networks and enables corresponding private investment. The theory notes, however, that the way infrastructure investments are financed may be non-neutral and there is the risk of a crowding-out effect on private investment, especially if these investments are financed through taxation or borrowing on domestic financial markets. In terms of indirect channels, infrastructure promotes economic growth through *maintenance and private capital durability*. It is plausible that infrastructure policy is biased toward the realization of new investments with less attention being paid to the detriment of the maintenance of the existing stock. This may be due to the political visibility of new investments and the fact that new investments often rely on low-interest international loans, which are more attractive to politicians as long as they do not have too many strings attached (see Rioja, 2003). Others include *Adjustment costs* where improvements in the stock of infrastructure capital are likely to reduce private capital adjustment costs (see Agénor and Moreno-Dodson, 2006); *Improvemens in Labour Productivity* through reduction in time wasted commuting to work and stress, less off-sick days, improved efficiency in organizing work time due to improved information and communication technology and learning by doing; *Improvements in Human Capital* as highlighted by Galiani *et al.*, (2005), in the short term by making existing stock of human capital more effective, and in the medium and long term by inducing additional investment in education; and finally *Economies of Scale and Scope*, where for example, better transport infrastructure lowers transport costs and leads to economies of scale, better inventory management. According to the theory, therefore, the importance of infrastructure for economic growth is highlighted.

Having established the relevance of infrastructure for economic growth, the question then arises as to how residual ownership of PPP projects impact the likelihood of success or failure of PPP projects. Its practical implications for complementing or impeding economic development can be significant, and the potential residual ownership implications for project survival is a motivation for this study.

[7] See Barro and Sala-i-Martin (2005) and Agénor and Moreno-Dodson (2006) who discuss and model several channels through which infrastructure may affect growth.

2.3 Incomplete contracting and PPPs

A popular theoretical proposition for risk allocation and the ownership of residual facility in PPPs is the *Theory of Incomplete Contracting* (TIC), which attempts to explain the so-called 'hold-up' problem emanating from the opportunistic behaviour of a contracting party during *ex-post* renegotiation due to the inability of the parties to write a complete contract *ex-ante* that will capture all possible contingencies (see Grossman and Hart (1986)). The basic tenet of the TIC is that economic agents are boundedly rational and cannot anticipate *ex-ante* all possible contingencies in a relationship. Therefore, they may write contracts that specify only the possible known contingencies and later on when the state of nature is realised, they can renegotiate to fill in the additional details. The main problem with this gap-filling solution relates to incentive-compatibility, i.e., whether or not the economic agents have the propensity to be truthful in their dealings during *ex-post* renegotiations. Clearly, in such high investment projects, importance of this in investment decisions can be significant. In fact, most developing countries have generally not been able to establish credible regulatory bodies because of governments' inability to commit e.g., the concessions granted to private operators following the divestiture of Latin-American public firms were renegotiated after an average of only 2.1 years (see Guasch 2004).

Following seminal works by Grossman and Hart (1986) and Hart and Moore (1988) (hereafter collectively referred to as GHM) on the TIC, the role of residual ownership on the outcomes of relationship-specific investments, such as PPPs garnered interest. Dewatripont and Legros (2005), however, highlight the problem of incentive compatibility i.e., whether or not the economic agents have the propensity to be truthful in their dealings during *ex-post* renegotiations. They highlight that incomplete contracts typically fail to fully protect economic agents against opportunistic behaviour, as it is difficult for third-parties to distinguish between good- and bad-faith renegotiation demands. According to Rogerson (1992, p. 777), a hold-up problem occurs when two factors are present. First, parties to a future transaction must make non-contractible specific investments prior to the transaction in order to prepare for it. Second, the exact form of the optimal transaction (e.g., how many units if any, what quality level, the time of delivery) cannot be specified with certainty *ex-ante*. To address the possible hold-up problem associated with incentive-compatibility, GHM suggest that when economic agents enter into a relationship in which the asset will be used to generate income, the agents can, in principle, contractually specify exactly who will have control over the asset during the contract period. In doing so, the authors focus on the ownership of residual rights (or the residual facilities) during the contract period in a two-period model of integration of two parties where the product emanating from the relationship is a private good. Besley and Ghatak (2001) extended GHM's model to evaluate the PPP framework for the production of a public good. They argue that if the value created by the investment of the partners constitute a public good then the partner with the highest valuation should be the owner of the residual facilities or have the control rights during the contract period irrespective of the relative importance of their investments or other aspects of the production technology. Francesconi and Muthoo (2011) extended the model further by considering public good in terms of the degree to which it can be classified as a public good and posit on who should then control the residual rights based on this classification and the level of investment. It follows from this theory that efficient assignment of rights, including risks, depends on the type of good or value generated as well as the choice or attributes of the parties entering into the partnership. Building on these earlier developments, developed a three-period model in an attempt to capture the role of residual facilities ownership at the expiry of the contract period and beyond. They conclude that ownership of the facility at contract expiration has an important role to play in incentivising partners' *ex-ante* investments for the maximisation of their joint surplus. Bennett and Iossa (2006) posit that the argument in favour of residual ownership by the private sector partner is strengthened when it is assumed that the partners' investments are unverifiable, consistent with the GHM model, in which case there can be no bargaining over the implementation of innovation, and thus the private sector partner is only motivated by concern for her own profit.

As the residual ownership net effect is unknown *a priori*, the extant literature highlights the risk associated with residual ownership - the so-called *Residual Value Risk*. Given the large number of PPP project failures, a crucial question for both practitioners and policy-makers, is how PPP residual facility ownership affects risk of failure (or enhances survival). Based on the above, our analyses assumes that survival of PPP projects is influenced by the cost associated with residual facilities ownership.

2.4 Testable hypotheses

On the one hand, if the residual facility ownership is conferred *ex-ante* on the private sector partner, given that this partner is motivated by concern for own profit, a premium will be included for the associated RVR and such costs will be incorporated *ex-ante* into the overall project cost. The ensuing increase in the overall project cost reduces affordability of the project output by end-users (if the project output is sold directly to end-users) and/or the fiscus (if the government is paying). On the other hand, if residual ownership is conferred on the public sector partner, given the assumed welfare-maximisation objective of governments, it is likely that the cost associated with the RVR will not be translated *ex-ante* into the overall project cost, thus reducing the present value of the tariff burden on end-users and/or the government fiscus.

To account for possible endogeneity in the relationship between residual facility ownership and the risk of PPP projects failure, and to understand how PPP project survival relates to other substantive predictors commonly used in the literature (e.g., Buso *et al.*, 2017; De Vries and Yehoue, 2013), we consider some control variables, including (i) size of project, (ii) participation of multilateral institution(s) in project arrangement and (iii) the participation of local sponsor(s) in the project arrangement in our empirical modelling. The rationale for these controls is as follows.

First, larger projects are typically more expensive; and this high cost is likely to be translated into the project output tariff, thereby reducing affordability for end-users and/or the government fiscus. Davis (1996) suggests that aside from the ability to pay for the project output, the willingness by the state and/or end-users to pay, because of an unreasonably high tariff, could affect the survival of the project.[8] Byoun *et al.*, (2013) note that project size can also increase project risk if the high-profile nature of a large project draws more attention from the local government, which might in turn increase the probability of the local government taking an adverse action. So, we test whether, *ceteris paribus*, small sized PPP projects are likely to have a lower risk of failure than large-sized projects.

Second, multilateral institutions, such as the World Bank (WB), the International Finance Corporation (IFC) and the European Bank for Reconstruction and Development (EBRD), have been active in PPP implementation across the world. Byoun *et al.*, (2013) suggest that participation of these institutions in PPP arrangements can mitigate the effects of adverse government actions and provide political risk insurance to protect sponsors (equity holders) against the risks of capital controls, expropriation, or other adverse and unexpected political events. In short, the participation of these institutions, particularly in the provision of guarantees, could have cost-reducing effects, as well as enhancing smooth implementation of PPP projects. In general, these institutions can participate at several levels of the project cycle, including (i) Financial - *provision of loans to the project* and *taking direct equity interest in the project* (ii) Provision of Guarantees - *partial risk guarantee* and *political risk guarantees* (iii) Risk Management Support - Some multilateral institutions provide currency hedging as well as interest rate risk management facilities for PPP projects (iv) Providing Advisory Services - multilateral institution also provide advisory

[8] A classic example being the Dabhol Power project in Maharastra, India, where both the off-taker (the Maharastra State Electricity Board (MSEB)) and the Federal Government of India "wilfully" defaulted on their guarantees under the project due to a high output tariff in the midst of an output glut, resulting from an oversized project.

services at different levels of project implementation. So, we test whether, *ceteris paribus*, PPP projects with the participation of multilateral institutions are likely to have lower risk of failure than those without.

Third, given that some investors could receive part or all of their investment proceeds in local currency. Foreign exchange pressure on the projects can contribute significantly to the failure of PPP projects, as occurred in the 1990s (see Estache (2003)). We test whether, *ceteris paribus*, PPP projects with the participation of local sponsor(s) are likely to have lower risk of failure than those without. Fourth, following Buso *et al.*, (2017) as well as the joint World Bank and International Monetary Fund (IMF) debt sustainability framework for low and middle income countries, public debt burden is captured through stock/solvency and flows/liquidity indicators. The solvency indicator often employed is the public and publicly guaranteed (PPG) debt as a percentage of nominal GDP (DstockGDP), which attempts to capture governments' ability to meet all long-term external debt obligations. So, we test whether, *ceteris paribus*, the higher the government revenue, the lower the likelihood of the risk of PPP project failure. In addition, we investigate whether, *ceteris paribus*, the lower the public sector debt burden, the lower the likelihood of risk of PPP project failure.

Fifth, both inflation and exchange rates have been linked to variables that directly affect PPP output tariff and hence, affordability and/or the fiscus); Osei-Kyei and Chan, (2015) also highlight the importance of output demand for PPP project survival. We therefore investigate whether, *ceteris paribus*, higher levels of inflation rate and exchange rate depreciation increase the likelihood of PPP project failure. Finally, some studies including Singh and Jun, (1995) have emphasised the role of political stability in the decision-making process and risk of failure of long-term investments such as PPPs. Countries with a high propensity for violence, especially fragile states, are likely to experience destruction of most of their long-term infrastructure investment and, most often, prevent government from meeting her PPP contract obligations as well as ordinary citizens from generating income to continue purchasing outputs of these investments. Therefore, we investigate the potential role of higher population and real GDP per capita on the likelihood of PPP project failure. Hence, we examine whether there is evidence to support the hypothesis that, *ceteris paribus*, the more politically stable a country is, the lower the likelihood of PPP project failure.

We note that although *duration analysis* has been applied across many disciplines, including medicine (see Kumar (2015)), labour economics and international relations (see Martinez-Garcia and Raya (2008)), its application in project finance, particularly PPPs, is limited. We apply duration analyses methods to data extracted from the World Bank's PPI database.

As in other areas of economics, endogeneity due to selection bias or reverse causality pose a problem for our analysis. For example, it is likely that unobservable variables that affect residual value (and ownership assignment) also affect the probability of project failure. Our analysis takes into account several covariates that may alleviate the endogeneity problem to some extent. However, we do not claim to have established irrefutable causal relationship between residual ownership assignment and project survival. However, our analyses demonstrate robust associations that governments will do well to consider when negotiating terms, particularly for PPP infrastructure projects.

3 Data and Methods

In line with our main aim of investigating whether PPP projects that confer residual facilities ownership on the public sector have lower risk of experiencing failure or rather, greater chances of survival, than those for which the private sector retains ownership, we test 'whether' and 'when' an event of PPP project failure occurs by employing the duration Analysis approach. We first describe our data and then explain the application of the duration analysis.

Aiming to address our main question on the association between the *Risk of PPP failure* and *Residual Ownership*, we analyse data compiled from the World Bank's Private Participation Infrastructure (PPI) database, which is appropriate as it corrects right censoring.[9] The dataset for the year ending 2015, has longitudinal data for projects that have private sector participation from 1980 to 2014 for low, lower-middle and upper-middle income countries across six regions: East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and the Caribbean (LAC), Middle East and North Africa (MENA), South Asia (SA) and Sub-Saharan Africa (SSA). Though the entire PPI dataset for 2015 consists of a total of 6530 projects, implemented across 139 countries, for our purposes our final sample consists of a total of 2721 projects, implemented across 114 countries.[10]

Table 1: Regional Distribution of Projects

	Total Number of		Total		Leading Country in Region		
Region	**Countries**	**Projects**	**Investment**	**%**	**Country**	**Project**	**Investment**
EAP	14	1041	217,662.8	24.6%	China	750	70,813.7
ECA	19	162	83,322.2	9.4%	Turkey	68	55,926.4
LAC	23	896	267,562.9	30.2%	Brazil	435	138,924.0
MENA	11	88	67,159.2	7.6%	Egypt, Arab Rep.	15	17,253.0
SA	8	345	170,480.2	19.3%	India	237	130,687.3
SSA	39	189	79,076.4	8.9%	Nigeria	16	28,007.7
Total	**114**	**2721**	**885,263.6**	**100.0%**		**1521**	**441,612.1**

Note: Investment is in millions of US$

Table 1 provides a summary of the regional distribution and total investment amount of the selected sub-types of PPI projects. The table shows that the EAP region has the highest number of projects, but the LAC region accounts for the greatest investment. However, in terms of the average investment per country in a region *((Total Investment in the Region)/(Number of Countries in Region))*, SA (US$21.3 billion) has the highest, followed by EAP (US$15.5 billion). The MENA region has the lowest number of projects, but its per country investment (US$6.1 billion) is greater than both ECA (US$4.4 billion) and SSA (US$2.0 billion). By far, China has the largest number of projects in its region and amongst the countries under consideration, while Brazil accounts for the greatest investment amount. Nigeria and Egypt have the highest PPI investment in their respective regions.

In terms of sectoral distribution, the Energy sector accounts for most of the projects, totalling 1326 projects across all the regions, followed by the Transport sector (664), while the Water & Sewerage, and Telecom sectors account for 17 and 10% respectively (see Figure 1).

The *status* field of the PPI dataset indicates whether the project is *concluded*, *cancelled*, *merged*, *operational*, *distressed* or *under construction* (see Appendix IB). Figure 2 shows that the majority of projects in all the regions are either operational or under construction. The LAC region has the highest number of both *cancelled* (68) and *concluded* (72) projects, while MENA has the lowest number and with no project in distress. According to the adopted definition of project failure in this study, which includes *cancelled*, *merged* and *distressed* projects, ECA region has the highest percentage of failed projects (20%), followed by SSA (15%), as shown in the line graph in Figure 2.[11]

A total of 375 projects have the participation of multilateral institutions, such as the World Bank and its affiliate organisations, the Asian Development Bank, the African Development Bank

[9] Censoring occurs whenever it is impossible to determine the exact time when a subject experiences the event of interest, which in this case is when a PPP project failure occurs. Both Cox and Oakes (1984) highlights the potential estimation bias of parameters when using data with right-censoring.

[10] We exclude (i) countries that do not have comprehensive macroeconomic, fiscal or political data e.g. Cuba, Eritrea and Democratic Republic of Korea (ii) all projects with no reported investment amount.

[11] *Merged* projects are included as 'failed', because the project, on the basis of the original contract, did not go to term and has had to be amended.

Figure 1: Sectoral Distribution of Projects

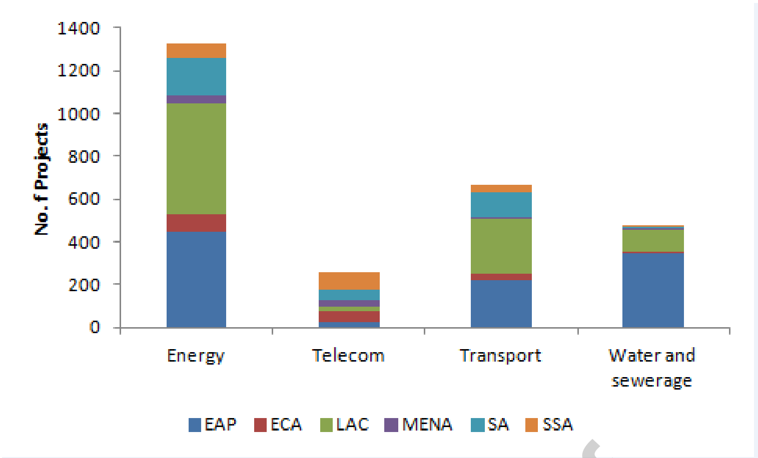
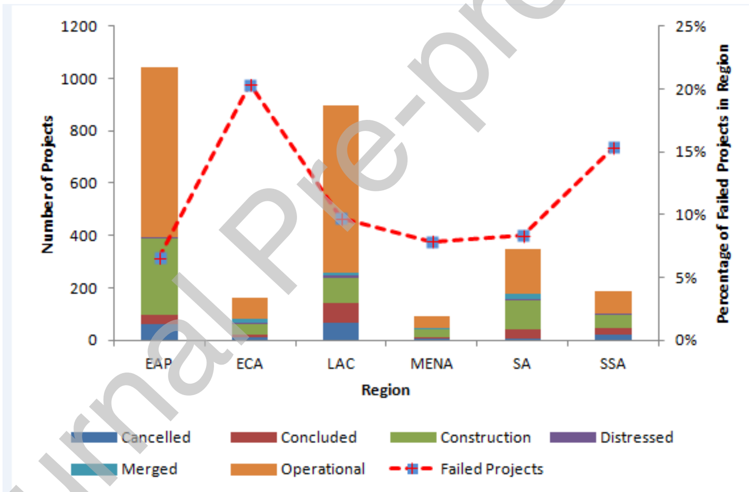


Figure 2: Project Status



etc., in the PPI arrangements, while 918 projects have the participation of local sponsors.

Our final data sample considers four out of the 12 possible sub-types of PPI projects, two (BOT and BOO) of which are regarded as typical PPP greenfield projects and thus, form the crux of our research. In addition to BOT (build, operate & transfer, where the residual facility of the project is transferred to the public sector after the expiry of an agreed concession period) and BOO (build, operate & own, where the private sector retains residual facility ownership), we consider ROT and Mct sub-types for robustness checks. There are a total of 1370 and 629 BOT and BOO projects respectively in the sample, with the EAP region accounting for most of these projects followed by the LAC region (see Table 2).

3.1 PPP failure definition

In this study, the event of interest is 'project failure', which is defined as a deviation of a PPP project outcome from the original conceptualisation by the partners. This definition conforms with the definition typically used in the extant literature, and aligns with the aims of our study. In

Table 2: Regional Distribution of PPI Sub-types

Types of PPI	EAP	ECA	LAC	MENA	SA	SSA	Total
Build, Operate, and Transfer (BOT)	680	45	424	44	138	39	1370
Build, Own, and Operate (BOO)	120	42	259	15	135	58	629
Merchant (Mct)	21	47	28	22	44	68	230
Rehabilitate, Operate and Transfer (ROT)	220	28	185	7	28	24	492
Total	1041	162	896	88	345	189	2721

Note: East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and the Caribbean (LAC). Middle East and North Africa (MENA), South Asia (SA) and Sub-Saharan Africa (SSA).

other words, any form of hiccup encountered by the project after financial closure, which changes the original agreement or structure and/or brings the project to an untimely end, is considered as an event of failure. Accordingly, a project is said to have experienced the event of failure if either of the following states apply:

1. It is in *distress*: According to the World Bank, this means that the government or the sponsor (the private partner) has either requested contract termination or are in international arbitration, thus paving the way for an untimely end of the project;

2. It is *merged* with another during operations: This is when there are changes the structure of the original project; and

3. It is *cancelled*: This leads to an abrupt end of the project.

Given that our analyses involves censored data, and Cox and Oakes (1984) and Hosmer and Lemeshow (1999) both expand on the advantages of duration analysis over the other techniques when dealing with censored event history data, we employ that approach in this study. The type of censoring we deal with in this study is right-censored, which is the most common form of censoring i.e. when the study comes to an end without the subject experiencing the event of interest, or when the subject drops out during the study period because something other than the event of interest occurred.[12] Thus, each project has a potential censoring time C_i or a potential lifetime T_i, which makes the observation, $Y_i = min(T_i, C_i)$. This implies that survival time of a project is considered to be at least as long as the duration of the study period. The censoring indicator δ shows whether or not the project is censored, or experienced the event of failure and is given as:

$$\delta_i = \begin{cases} 0 & \text{if } T_i > C_i \quad \text{(censored)} \\ 1 & \text{if } T_i \leq C_i \quad \text{(event of failure)} \end{cases}$$

In line with recommendations in previous literature (see examples Broström, (2012), Jenkins, (2005), and Singer and Willett, (2003)), the censored projects were not discarded from the final dataset because doing so would introduce bias in the analysis as most of the information about PPP projects longevity would have been lost in the process, noting that a large number of PPP projects survived for a long period of time before being censored.

3.2 Time considerations

To determine the appropriate model for carrying out our analyses, we ascertain whether time should be treated as continuous or discrete. Since the World Bank's PPI database does not contain a field that explicitly shows year of project failure, we determine the event year information from the (i) The *Contract Period*, which is sometimes referred to as the concession period i.e.

[12]See Appendix I for additional detail.

the expected implementation period of the project. (ii) The *Termination Year*, which is the anticipated end year of the project as stated in the agreement signed between the partners. (iii) The *Investment Year*, which is otherwise known as the disbursement year, and is the period over which funds are released into the project. Funds can be released in annual granularity up to several years. (iv) *Date status updated* i.e. the date when the World Bank's PPI team updates the status of the project and (v) *Project Status*, which indicates whether the project is, for example, *cancelled* or *concluded*.

For precision, we do not simply take the *termination year* to be the event year since it is possible that a project will not survive up to its anticipated end date, nor do we take the *date status updated* without due care for other factors because on that date the *project status* might indicate that the project is 'operational', meaning that it did not experience the event of failure as at the end of the study period.

3.3 Variables description

All variables are defined for each project i and for each year j until the project experiences the event of failure or is censored. Table 3 presents a summary of the description of the variables and *a priori* expected signs.

Table 3: Variables Description

Variable	Abbreviation	Definition	*A priori* Expectation	Note
Dependent Variable				
Project Failure	Failedij	Equal to 1 if the project i failed at time j and 0 if the project does not fail		
Independent Variables				
(1) Variables on project characteristics				
PPP Sub-type				
	BOO	Build Operate and Transfer	Positive	Relative to BOT
	BOT	Build Own and Operate	Negative	Relative to BOO
	BOT*Spell	Interaction between PPP Sub-type and operation period (in years)		
Project Size				
	Size_medium	Medium size project	Negative	Relative to Large Size
	Size_small	Small size project	Negative	Relative to Large Size
Participation of Multilateral Institutions (Yes=1)				
	Mult_Part(0)	No multilateral participation	Positive	Relative to Mult_Part (1)
Local Sponsor Participation (Yes=1)				
	L_Spon_Part(0)	No local sponsor participation	Positive	Relative to L_Spon_Part (1)
Sector				
	Telecom	Telecommunication		
	Transport	Transport		
	W & S	Water and Sewerage		
Region				
	ECA	Europe and Central Asia		
	LAC	Latin America and the Caribbean		
	MENA	Middle East and North Africa		
	SA	South Asia		
	SSA	Sub-Saharan Africa		
(2) Variables on country characteristics				
Market Variables				
	LPopn	log of population	Negative	In the model all of
	LGDPPC	log of GDP per Capita	Negative	these variables have the
Fiscal Constraint Variables				prefix C and some KC.
	LDSerExP	log of debt service to export of good and services	Positive	The C means that the variable is centered
	LDstockGDP	log of debt stock to GDP		from its mean and the
	LRev_GDP	log of government revenue to GDP	Negative	KC means the variable
Macroeconomic Constraint				is both centered and
	infl	inflation	Positive	categorised, which helps to
	LEXRate	log of exchange rate	Positive	determine whether the
Political Constraint				effect of the variable
	PV.EST	Political stability and absence of violence	Negative	is non-linear

As is the case with survival models, our response variable consists of two parts: the first part gives a binary outcome - indicating whether or not the event of failure occurs; while the second part shows the time in years until project failure or censoring. Our main explanatory variable, *PPP Sub-types*, is a dichotomous variable with 1 representing a BOO project and 0 for a BOT project. The data for this variable is a subset of the data in the 'PPI-Subtype' field of the World Bank's PPI dataset.[13]

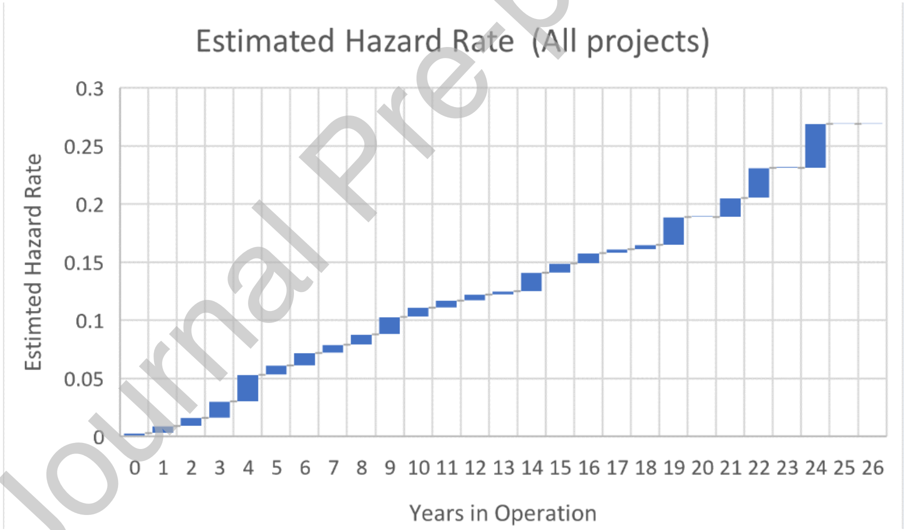
3.4 Survival and hazard functions

Using the hazard function ($h(t_{ij})$) as the function that gives the instantaneous potential in each year in operation for a PPP project i to experience the event (failure), given that it has survived up to year j, the estimated discrete-time hazard function for year in operation j is calculated as:

$\hat{h}(t_{ij})$= [No. of failed projects in year in operation (j)] / [No. of projects at risk of failure in year in operation (j)]

Table 4, a *Life Table* for the PPP data summarises the sample distribution for event occurrence. Columns 2 and 3 report the number of projects at risk of experiencing failure during a given year of operation and the projects that failed in each year of operation respectively. The Hazard and Survival rates are reported in Columns 5 and 6 respectively.

Figure 3: Estimated year by year hazard rate as reported in Table 4



The survival function ($S(t_{ij})$) assesses the probability that project i will experience failure after surviving up to year j, and is formally written as [14]:

$$S(t_{ij}) = Pr[T_i > j] \tag{2}$$

The estimated discrete-time survival function is written in terms of the hazard function as:

$$\widehat{S(t_{ij})} = [1 - \hat{h}(1)] \times [1 - \hat{h}(2)] \times \cdots \times [1 - \hat{h}(j-1)] \tag{3}$$
$$= \hat{S}(j-1) \times [1 - \hat{h}(j-1)] \tag{4}$$

[13]See Appendix II for a fuller description of these variables.
[14]In other words, the survival function cumulates the period-by-period risks of project failure.

Table 4: Life Table for PPP Projects

	Number of				
Years in Operation	Projects at Risk	Failed Projects	Censored Projects	Hazard Rate	Survival Rate
0	2721	9	87	0.003	0.997
1	2625	16	125	0.006	0.991
2	2484	17	152	0.007	0.984
3	2315	33	157	0.014	0.970
4	2125	48	107	0.023	0.948
5	1970	16	114	0.008	0.940
6	1840	21	148	0.011	0.929
7	1671	12	179	0.007	0.923
8	1480	13	162	0.009	0.915
9	1305	19	168	0.015	0.901
10	1118	9	116	0.008	0.894
11	993	6	138	0.006	0.889
12	849	4	124	0.005	0.885
13	721	2	103	0.003	0.882
14	616	10	126	0.016	0.868
15	480	4	51	0.008	0.861
16	425	4	72	0.009	0.852
17	349	1	104	0.003	0.850
18	244	1	75	0.004	0.847
19	168	4	60	0.024	0.826
20	104	0	41	0.000	0.826
21	63	1	23	0.016	0.813
22	39	1	9	0.026	0.792
23	29	0	3	0.000	0.792
24	26	1	11	0.038	0.762
25	14	0	10	0.000	0.762
26	4	0	2	0.000	0.762
27	2	1	1	0.500	0.381

Note: This table cumulates all projects from 1986 to 2014 and then groups them according to the number of years for which they survived before experiencing the event of failure or are censored. For example, out of the 2721 projects in the dataset, 9 experienced the event of failure while 87 were censored within 1 year of operation. The table does not report the year when the event of failure or censoring occurred.

The graphical illustration of the estimated hazard function (see Figure 3) suggests a cyclical behaviour of the hazard rate of PPP failure, with a jump in the risk of PPP project failure at fairly regular intervals. This appears to coincide with political election cycles, which are run typically every 5 years; and the risk of project failure may be impacted by the PPP stance taken by the incoming party.[15]

Aiming to determine whether BOT projects have lower risk of failure than BOO projects, we fit an appropriate statistical model of hazard to the variable representing the types of PPP projects along with all identified control variables.

[15]The potential link between political election cycles and PPP project failures, as suggested here, is an area for future research.

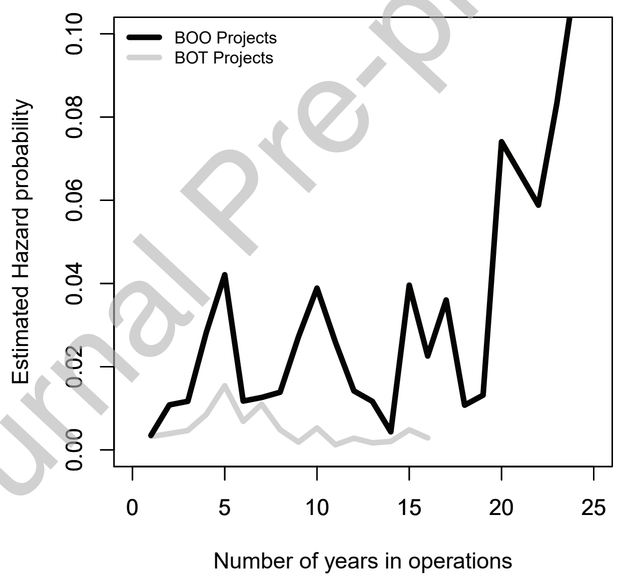
3.5 Kaplan-Meier non-parametric survival approach

In the literature of survival analysis, there are two main types of non-parametric estimators of the hazard and survival functions: the Kaplan-Meier (KM) and the Life-table estimators. Here, we focus on the KM estimator, as it incorporates information from all observations, whether censored or uncensored (Bosco Sabuhoro *et al.*, 2006). The KM survival function for PPP projects is given by the product of one minus the number of projects that experienced the event of failure in year j of operation, d_j, divided by the number of projects at risk of experiencing failure in that same year, n_j (i.e. the number of projects at risk of ending their spell immediately prior to time t_j). This can be written as:

$$\widehat{S}(t_j) = \prod_{j|t_j<t} \left(1 - \frac{d_j}{n_j}\right) \tag{5}$$

where $\frac{d_j}{n_j}$ is the ratio of the number of failed projects to the number of projects at risk of experiencing the event failure.[16]

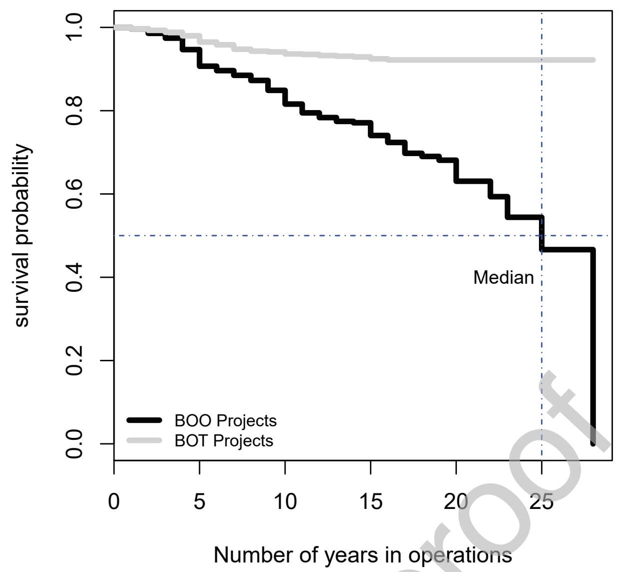
Figure 4: Hazard Functions for BOT and BOO Projects



First, from Figure 4, we infer that BOO projects appear to be riskier than BOT projects, as they have higher odds of experiencing the event of failure. It also suggests that the risk of failure for BOO projects is elevated after every five years, while for BOT projects, the risk gradually dissipates after the first five years of operation. On the whole however, the hazard functions for both BOT and BOO projects appear to have multiple distinctive peaks and troughs, which may indicate non-monotonicity. Second, from Figure 5, we infer that the survival functions for the two types of PPP projects clearly suggests that BOT projects have higher chances of survival compared to BOO projects.

[16]This ratio is also referred to as the hazard rate.

Figure 5: Survival Functions for BOT and BOO Projects



3.6 Discrete time hazard approach

Next, we employ the discrete-time hazard modelling approach proposed by Cox (1972a), where the discrete-time hazard (a conditional probability) is transformed into its *odds* or *log odds* thereby preserving its lower and upper bounds of 0 and 1 respectively. Following from this and the recommendations of Singer and Willet (2003), we employ a *logit* transformed model for this study which tends to maintain a proportional distance between the BOT and BOO hazard curves, while the gap widens for the *odds* transformation. Generally, the logit model can be written as:

$$\begin{aligned}\mathbf{logit}[h(t_i)] = &\sum_{j=1}^{n} \alpha_j D_{ij} + (\varphi_1 Z_{1i} + \varphi_2 Z_{2i} + \cdots + \varphi_m Z_{mi}) \\ &+ (\beta_1 X_{1ij} + \beta_2 X_{2ij} + \cdots + \beta_p X_{pij})\end{aligned} \tag{6}$$

where the first term on the right hand side, the αs multiplied by their respective time indicator (time dummies) D, act as multiple intercepts, one per period, which as a group represents the baseline *logit* hazard function, i.e., the value of the *logit* hazard when all substantive predictors are zero. The φs and βs multiplied by their respective substantive predictors, represent the shift in the baseline *logit* hazard function corresponding to unit differences in the associated predictors while holding the other predictors constant. Z_{1i} represents the time-invariant covariates, while X_{1ij} represents time varying covariates.

Using the variables in this study, Equation 6 is re-written as:

$$\begin{aligned}\mathbf{logit}[h(t_i)] = &\sum_{j=1}^{29} \alpha_j D_j + \varphi_1 \mathrm{PPI\_Subtype}_i + \varphi_2 \mathrm{Size}_i + \varphi_3 \mathrm{L\_Spon\_Part}_i \\ &+ \varphi_4 \mathrm{Mult\_Part}_i + \varphi_5 \mathrm{Region}_i + \varphi_6 \mathrm{Prim\_Sec}_i + \beta_1 \mathrm{DstockGDP}_{ij} \\ &+ \beta_2 \mathrm{DSerExp}_{ij} + \beta_3 \mathrm{GDPPC}_{ij} + \beta_4 \mathrm{Infl}_{ij} + \beta_5 \mathrm{ExRate}_{ij} \\ &+ \beta_6 \mathrm{Popn}_{ij} + \beta_7 \mathrm{Rev\_GDP}_{ij} + \beta_8 \mathrm{PSAV}_{ij}\end{aligned} \tag{7}$$

The model stipulates that project i's value of *logit* hazard in period j depends on the value of all time-invariant covariates (e.g., size of the project), which remain constant across time, and all the values of the time-varying covariates (e.g., inflation) in time period *j*. All the time-varying covariates in this model are communal, which means that they take different values in each time period. Time-varying covariates can take the following forms: (i) Factor - e.g., civil, status, which indicates whether someone is married or not. This status may change over time. (ii) Continuous covariates - this is a time-dependent variable that changes over time but these changes are known exactly, e.g., age, election cycle, etc. This type of time-varying covariate has the danger of reversed causality as explained by Singer and Willett (2003, p. 436). (iii) Communal (external) covariates - these are time-varying covariates that vary over time and are not within the subject's control i.e., exogenous. It is a special case of a time-varying covariate, but without the danger of reversed causality (see Broström, 2012: p. 68).

Next, inclusion of time as a categorical variable with a category for each year of operation yields a step-function. However, using 29 time dummies in even the presence of large project-year dataset may make the model perform poorly, and result in a baseline hazard function that may fluctuate erratically in the later periods; and inestimable in the early periods, when no project is reported as failed (see Singer and Willett, 2003). Following recommendations by Allison (1982) and Singer and Willett (2003), we explore other specifications including linear, quadratic, pth-order quadratic and log specifications.

Table 5: Representation of Time

			Difference in deviance in comparison to ...		
Representation of TIME	Number Parameter	Deviance	Previous Model	General Model	AIC
constant	1	2716.1		377.2	2718.1
linear	2	2404.0	312.1	65.1	2408.0
quadratic	3	2396.9	7.1	58.0	2402.9
cubic	4	2393.8	3.1	54.9	2401.8
fourth order	5	2393.0	0.8	54.1	2403.0
log	2	2428.4	-35.4	89.5	2432.4
General	29	2338.9	–	–	2394.9

5% Critical Value = 3.84

Table 5 presents a comparison of the deviance and Akaike Information Criterion (AIC) statistics for various time specifications. Considering both the AIC and the difference in deviance criteria, this study adopts the quadratic specification, which has one less parameter and yet is not significantly different from the cubic specification, to fit the final empirical model, which is given as:

$$\begin{aligned}\mathbf{logit}[h(t_i)] = & \, ONE + (Spell - 5) + (Spell - 5)^2 + \varphi_1 \text{PPI\_Subtype}_i + \varphi_2 \text{Size}_i \\ & + \varphi_3 \text{L\_Spon\_Part}_i + \varphi_4 \text{Mult\_Part}_i + \varphi_5 \text{Region}_i + \varphi_6 \text{Prim\_Sec}_i \\ & + \beta_1 \text{DstockGDP}_{ij} + \beta_2 \text{DSerExp}_{ij} + \beta_3 \text{GDPPC}_{ij} + \beta_4 \text{Infl}_{ij} \\ & + \beta_5 \text{ExRate}_{ij} + \beta_6 \text{Popn}_{ij} + \beta_7 \text{Rev\_GDP}_{ij} + \beta_8 \text{PSAV}_{ij}\end{aligned} \tag{8}$$

where *ONE* and *Spell* is a matrix of ones, included to capture the constant term, and *Spell* represents each year of project survival.[17]

For the Discrete-time model analyses, we employ five logit-link models:

[17] 5 is specifically used to center time (*Spell*) because the hazards of the BOO and BOT projects have their first peak during the fifth year of project operations and while the hazard for BOO projects elevates approximately every five years thereafter, the hazard of BOT projects gradually dissipates.

Model 1: Only one explanatory variable i.e. *PPP Sub-type*. Aims to investigate the relationship between residual facilities ownership (*PPP Sub-type*) and the risk of PPP project failure without consideration for potential endogeneity.

Model 2: Model 1 *plus* additional explanatory variables that relate to the characteristics of PPP projects, including the project size, the participation of multilateral institution and local sponsors in the project arrangement as well as the regional and sectoral placement of the project.

Model 3: Model 2 *plus* variables that relate to the characteristics of the country where the project is implemented, including fiscal, macroeconomic and market as well as political variables. Effectively, this model checks for potential confounding factors arising from both project and country characteristics.

Model 4: Model 3 with the incorporation of an interaction term between residual ownership (PPP Sub-type) and time (Spell-5), thus allowing for the difference between BOT and BOO projects to differ in each year of project operations. The aim here is to investigate whether or not the hazards of *PPP Sub-type* are non-proportional over time, that is testing whether the proportionality assumption holds.

Model 5: Similar to Model 4, except that the communal variables (these are the variables that relate to the characteristics of the country where the project is implemented) are stratified in an attempt to investigate the possibility for non-linearity between them and the risk of PPP project failure (see Singer and Willett, 2003).

Although Cox (1972b) proposes a partial likelihood method similar to that for continuous-time data, it is also known to be computationally demanding when several projects are experiencing the event of failure at the same time, and is therefore unattractive. The proposed alternative is to use the more conventional method of maximum likelihood (ML), which seeks to estimate population parameters (which in the case of this study are αs, φs and βs) that maximise the likelihood of observing the sample data.[18] Tables 7-9 in the Appendix IIB report the full results, including Model 5, our preferred model.

In addition to the above, for robustness checking, we first employ a matching strategy to match BOT to BOO projects in order to ascertain causal inference of residual facility ownership on the risk of failure of PPP projects. Second, two additional PPI sub-types were included in the model to verify whether indeed projects that confer residual ownership to the public sector have lower risk of failure. These results are reported in the Appendix IIC.

4 Empirical Results and Discussion

4.1 Results

4.1.1 *Kaplan-Meier Non-parametric Survival Model results*

Starting with the main explanatory variable, PPP Sub-type, Figure 5 illustrates that PPP projects which are structured as BOT, that is, projects that confer residual facilities ownership on the public sector at the expiry of the contract, have higher chances of survival than BOO projects, under which residual ownership is assigned to the private sector.

Table 6 shows that, on average, BOT projects survive approximately five years longer than BOO projects (using the Restricted Mean (R-mean)). The Mantel-Haenszel and the Peto & Peto tests were used to check for the significance of the difference between the two groups. In essence, these tests check whether it is necessary to differentiate between the two PPP sub-types.[19] Both tests show a highly significant difference between BOT and BOO projects in terms of their survival

[18] We follow the ML procedure outlined by Singer and Willett (2003, pp. 381-384).

[19] The null hypothesis of the tests is that there are no within-groups differences. These tests are chi-square tests with degree of freedom equal to the number of within-groups minus 1. For example, the degree of freedom for PPP Sub-type is 1 and that of Size is 2.

Table 6: Logrank Test of Significance for Difference in Within-groups Variables

	R-mean	Mantel-Haenszel test (Rho = 0)		†Peto & Peto (Rho = 1)	
		Chisq	P-value	Chisq	P-value
PPP Sub-types		114	0.000***	110	0.000***
BOO	21.1				
BOT	26.4				
Size		44.8	1.84e-10***	44.3	2.42e-10 ***
Large	22.6				
Medium	24.2				
Small	25.7				
Multilateral Participation		0.3	0.578	0.3	0.566
No	24.6				
Yes	24.9				
Primary Sector		162	0.000***	158	0.000***
Energy	25.1				
Telecom	18.8				
Transport	25.0				
Water & Sewerage	24.8				
Local Sponsor Participation		18.1	2.05e-05***	18.1	2.14e-05 ***
No	23.1				
Yes	25.4				
Region Grouping		60.3	1.08e-11***	56.9	5.2e-11***
EAP	24.2				
ECA	16.6				
LAC	22.9				
MENA	23.9				
SA	23.0				
SSA	22.2				

†Peto & Peto modification of the Gehan-Wilcoxon test

rate. We also find that small size projects have higher probabilities of survival than both medium and large size projects, and in turn, medium size projects have higher probabilities of survival than large size projects. These differences in survival probabilities of the various sizes are also indicated to be significant as shown in Table 6. On average, small size projects can survive approximately a year and a half longer than medium size projects and three years longer than large size projects.

Second, we find that participation of local sponsors in PPP arrangements increases the probability of survival of the project, while Table 6 indicates that projects with local sponsor participation survive, on average, by an extra two years when compared to projects without local sponsors', participation, a difference that was also found to be significant.

Third, the survival functions for multilateral institutions' participation in PPP arrangements indicate that there is no difference between a project that has the participation of multilateral institutions and one that does not. To buttress this point, Table 6 shows that multilateral participation in PPP project arrangement only increases the survival of the project, on average, by about 4 months and both the Mantel-Haenszel and Peto and Peto tests suggest this difference is not significant.

Fourth, in terms of regional grouping (see Figure 6 in Supplementary Appendix), we find that for the first 10 years of operation, the survival of PPP projects is very similar across all the regions. However, beyond this period, project survival becomes very different with ECA registering the lowest survival rates, followed by SSA, while SA and LAC remain almost indistinguishable and so are EAP and MENA until 20 years of operation.

Table 6 further confirms the graphical output and indicates that there is a significant difference in project survival in the various regions with ECA on one extreme, registering, on average, 16.6 years of survival and EAP on the other extreme, 24.2 years.

Finally, for sectoral grouping (see Figure 7 in Supplementary Appendix), we find that while the survival rates are similar for the Energy, Transport and Water & Sewerage sectors (restricted mean year of survival of around 25 years), the rate for Telecom is significantly lower with a restricted mean year of survival of 18.8 years.

4.1.2 ***Discrete-time Hazard Models Results***

To evaluate whether there is an improvement from one model fit to another, we make a comparison between the difference in the deviation of two successive models to a 5% critical value of a *chi*-square distribution with degree of freedom equal to the difference in the number of parameters between the two models. The AIC statistic are also considered to aid the selection.

Based on the above procedure, our results suggest **Model 2**, (with AIC and deviation values of 2141.9 and of 2109.9 respectively) appears to be better than **Model 1** (with AIC and deviation values of 2343.8 and 2335.8 respectively). The superiority of **Model 2** is confirmed by the highly significant chi-square test value (225.9***). Next, we find **Model 3** to be better than **Model 2**, thus indicating that in addition to project characteristics, there are country characteristics that confound the relationship between residual facilities ownership and the risk of PPP project failure in the model. **Model 4** provides sufficient evidence for the violation of the proportionality assumption made in **Model 3**. Finally, **Model 5** confirms that in addition to the violation of the proportionality assumption, the relationship between the communal variables and the risk of PPP project failure is non-linear. As a result, our study settles for **Model 5** to interpret the relationship between residual facilities ownership and risk of PPP project failure.

Our results indicate that there is a highly significant difference in the risk of failure between small and large size projects. The odds of small size projects experiencing the event of failure are about 36% of that of large size projects, while the odds of medium size projects are about 72% of that of large size projects. Both local sponsors and multilateral institutions' participation in PPP project arrangements were found to be insignificant in explaining the risk of project failure, albeit the negative signs of their respective coefficients are consistent with *a priori* expectations, indicating that their participation reduces the risk of experiencing the event of failure. Sectoral heterogeneity is found to be highly significant in explaining the risk of PPP project failure. The odds of experiencing project failure in the Telecom sector are about 6 times that of the Energy sector, while the odds of the other two sectors (Water & Sewerage, and Transport) are approximately three times that of the Energy sector. The implication is that projects implemented in the Telecom sector are comparatively more susceptible to failure. Across the different regions, only the MENA region exhibits significant difference with the benchmark region, EAP. The odds of PPP project failure in the MENA region is about 23% that of the EAP region. The effect of the market constraint variables, Population and GDP per capita, on the risk of project failure appears to be non-linear, albeit insignificant.[20] In terms of the macroeconomic variables, countries with high inflation rates have significantly high risk of project failure, so are countries with high exchange rates. Two out of the three fiscal constraints variables considered in this study, *debt service to exports* and *government revenue to GDP* are significant in explaining the risk of PPP project failure. Consistent with *a priori* expectations, high revenue to GDP ratios have a decreasing effect on the risk of project failure. Also, the coefficient of the Political constraint variable, $PV.EST$, has the right sign consistent with its *a priori* expectation, albeit not statistically significant in explaining the risk of project failure.

4.2 Discussion

Hart (2003) posits that granting of residual rights to a particular party in an agreement motivates that party to increase her *ex-ante* investment in the relationship. This could be the case when

[20]The linearity assumption is determined in this case by examining the pattern of parameters (and accompanying standard errors) for the system of dummies. With equally spaced predictors categories, a linear effect will lead to successive estimates being 'equi-distant' (see Singer and Willett, 2003), which is not this case here, thus suggesting non-linearity.

residual facilities ownership is conferred on the public sector, which could incentivise the sector to provide more support in order to ensure the success of the project, particularly if the project has positive residual value that is of the nature of a public good and will potentially enhance the development process in line with the 'big-push' theory. The motivation for optimal public sector *ex-ante* investment could also come from the fact that governments that successfully implement infrastructure projects for which they retain ownership are able to use the achievement to gain political advantage.

Given the possibility that the PPP project will end up with net negative residual value and parties cannot absolutely determine this *ex-ante*, the party upon whom residual ownership is conferred may acquire an asset or a liability. With the assumption that the private sector is motivated by profit, if allocated the residual facilities, any anticipated risk associated with the facility would be costed and incorporated into the project output tariff. This might not necessarily be the case if the public sector assumes the risk of residual facilities ownership (the RVR). Therefore, this reality may explain why private sector ownership of the residual facilities tends to lead to increased project costs and hence output affordability, which could lead to premature termination of the project. The public sector, assumed not to be motivated by profit, but rather citizens' welfare and economic development, even if for self-centered or political reasons, has the tendency of absorbing some of these costs. Hence, when residual ownership is given to the public sector, there is a higher likelihood that the cost of decommissioning a project would not be borne directly by the end-users, thereby making the project affordable, which may enhance pro-poor growth.

Our results highlight the importance of project size *vis-à-vis* the risk of project failure. Small size projects appear to have lower risk of failure, followed by medium size projects.[21] This outcome buttresses the point made about project affordability to the end-users and/or the *fiscus*. Large size projects normally result in higher output tariffs, which could prove unaffordable and have the tendency in the medium to long-term to restrict public policy choices or final consumer demand for cheaper alternatives in the presence of technological advancement.

Although participation of multilateral institutions and local sponsors have only been recently gaining momentum, the role on the reduction of risk of failure of PPP projects is yet to be realised. However, our results highlight a significant issue for economic development i.e., sectoral heterogeneity in risk of PPP project failure. The following sectors rank highly in developing countries' developmental objectives. Projects implemented in the *Energy sector* (which are mostly structured as BOT) exhibit the lowest risk of failure, followed by the *Transport sector*. Projects in the *Telecom sector* (which are mostly structured as BOO) have the highest risk of failure. It is worth highlighting that the *Telecom sector* is characterised by merging and sale of assets as operators try to gain greater competitive edge or profitability.[22] As noted by Chan-Olmsted and Jamison (2001, p.2), since the passage of the Telecommunications Act in 1996, the US has witnessed multiple mergers of leading telecommunications companies, including between TCI, Media One and AT&T and MCI Worldcom and Sprint, all in an attempt to gain "competitive advantages through strategic combinations of resources and presence in multiple product and geographical markets". This is also evident in developing countries e.g. AirTel and Africell in Sierra Leone.

Further, from the regional perspective, our results suggest that PPP projects implemented in the MENA region have the lowest risk of experiencing event of failure. We find that the highest risk of project failure is in the EAP region, followed by the LAC region. This could be attributed to their early engagement in PPPs, at a time when the framework was less understood and mistakes abounded. On the other hand, projects implemented in the MENA and SSA regions showed relatively lower risk of failure, as these regions started implementing PPP projects much later and therefore, had the opportunity to learn from the mistakes of early implementers. However,

[21]Recall, *size* is measured as a ratio of the total investment in a project to the GDP of the country where the project is implemented.

[22]It should be recalled that the definition of failure in this research includes *merged* projects.

we note that, for the early adopters (EAP and LAC regions), since the results are based on averages, the failures in earlier years could bias recent achievements made by these regions, which are now considered as the leading regions in the implementation of PPPs. Developing countries engaging in PPPs for development will need to *a priori* learn from other countries' experiences.

We highlight that our results indicate that variables representing governments' ability to meet their obligation under PPP arrangements are highly significant. *Public debt service to GDP ratio*, a measure of government's inability to quickly raise debt, especially from non-residents to meet liquidity shortfalls, is statistically significant and demonstrates a positive relationship with the risk of project failure. This means that a country that finds it difficult to raise debt to meet emergency liquidity problems are at greater risk of experiencing PPP project failure. Developing countries engaging in PPPs for development will need to *a priori* have sustainable debt levels, plus a good record of reserves.

We find the macroeconomic variables (Inflation and Exchange rate) to be statistically significant, thus impacting project affordability. Countries with high inflation and exchange rates are more vulnerable to experiencing PPP project failure, as increases in these indicators directly lead to higher output (local) prices, thereby becoming unaffordable for end-users, particularly the poor and hence, serving as a catalyst for project failure. Developing countries engaging in PPPs for development will need to *a priori* stabilize these macroeconomic indicators.

Our finding that *political instability* was not a significant factor in explaining PPP project failure is worth highlighting. We note that several PPP arrangements, especially those with the involvement of multilateral institutions, incorporate mechanisms to insure against temporal political instabilities, hence it becomes less of a concern. For example, the Multilateral Investment Guarantee Agency of the World Bank includes in PPPs arrangements political risk insurance and credit enhancement guarantees aiming to facilitate project success, particularly in developing and emerging countries.[23]

Finally, based on our analyses of the discrete-time hazard function, it appears that the risk of PPP project failure spikes after every five years of project operation, and more so for BOO projects, which is also consistent with the political cycle of most of the countries in the study. Further, the MENA region, where until recently most of the countries, including Egypt, Libya, Morocco and Jordan, have unlimited political term limits, has the lowest risk of project failure. This may suggest that a more stable and predictable political system with uninterrupted PPP government policies appears to reduce the risk of project failure.[24]

Overall, our results provide evidence supporting the hypothesis that PPP projects that are structured to confer residual facility ownership on the public partner have lower risk of experiencing failure or rather, have a higher survival rate, than those that confer such ownership on the private partner. We infer that public partner residual ownership helps to make PPP projects affordable. The public partner is assumed to be motivated purely by citizens' welfare and not profit and therefore, likely to absorb some of the costs including residual value risk, rather than transferring such costs to the end-users. Intuitively, such support from the public partner is crucial for project affordability and hence, longevity. In cases where such support is not provided e.g., the Paiton project in Indonesia and the Dabhol project in India, project affordability did become a challenge, and led to project failure (see Davis, 1996).

Second, and as elucidated by Hart (2003), granting of residual ownership to the public partner could motivate them to increase government's *ex-ante* investment in the relationship, particularly if the project has positive residual value i.e., project is of the nature of a public good. Further, motivation for optimal public partner *ex-ante* investment could also come if the public partner intends to showcase the project's success to gain political capital. It is commonplace for incumbent political parties to make claims that most of the existing infrastructure in their country were

[23]See Multilateral Investment Guarantee Agency of the World Bank website. at https://www.miga.org/Pages/Who%20We%20Are/Overview.aspx

[24]We note, however, that we cannot draw conclusive inferences on this from our analyses on this particular issue.

developed during their tenure in power under various partnership arrangements e.g., several political commentators view Sierra Leone's August 2007 presidential elections to have been won based on such campaign claims by the then incumbent. On the more positive side, following the election win, the party embarked on elaborate infrastructure programs (especially roads), mostly through PPPs, to consolidate its political gains. To buttress this point, more recently, both Ghana's 2012 and 2016 presidential elections' main campaign promises of the respective incumbents i.e., 'Advancing a Better Ghana' and 'One District One Factory', bear testament to this fact.

5 Conclusions and Policy Recommendations

The central issue this study addresses is how residual ownership of PPP projects affects infrastructure project survival. We posit that how governments negotiate this should not be underestimated, particularly for developing and emerging economies. Given the well-documented importance of infrastructure for economic growth and development, many in the development and policy community, including international institutions like the World Bank, have called for a 'big push' in infrastructure investments in developing countries for economic development. Based on the extant literature, this study developed several hypotheses relating the role of residual ownership in the survival of infrastructure projects. The main tenet of the hypotheses being that since there is Residual Value Risk associated with the ownership of the residual facility in long-term relationships like PPPs, such ownership should be bestowed upon the partner that is less likely to translate the costing of this risk into the overall project cost, thereby enhancing project affordability, even for the poor, and hence longevity.

Analysing a sample of 2721 PPP projects across four major sectors (*Energy, Telecom, Transport and Water & Sewerage*) from 114 developing and emerging countries in six regions (EAP, ECA, LAC, MENA, SA and SSA), we conclude the following: First, governments should know that factors crucial for the survival of the project include *project size*, since large-sized projects appear to be more susceptible to failure than small-sized projects. Thus, governments, tasked with policy and decision-making should resist the temptation to undertake unsustainably large-sized PPP projects. Second, *Energy* sector projects appear to have lower risk of failure than *Telecom* sector projects. Energy projects, which are fundamental for economic development appears an attractive PPP route developing economies may want to consider. Third, it is incumbent on governments to learn from other countries' experiences. The MENA region, for example, had the lowest risk of PPP project failure compared to EAP and LAC. We infer that unhindered public sector support and learning from the lessons of earlier implementers could actually reduce the risk of project failure for developing economies. Fourth, risk of project failure is mitigated when governments have strong ability to generate revenue or raise debt within the shortest possible period to meet contingent fiscal obligations. Particularly those arising from the crystallization of contingencies under PPPs. Developing countries should aim to maintain sustainable debt levels and credibility in the capital markets. Fifth, governments need to prioritise macroeconomic stability since macroeconomic variables such as inflation and exchange rates affect PPP project output tariff and hence, output affordability and can influence risk of PPP projects failure. High exchange and inflation rates increase the propensity of PPP project failure, thus further buttressing the point that the cost of the project is very crucial for its survival.

Given both the direct and indirect implications of infrastructure investments for economic growth and development, thorough consideration of PPP residual ownership risk is crucial, hence some policy recommendations are instructive.

First, contrary to Bennett and Iossa (2006), we conclude that residual facility ownership should be given *ex-ante* to the public sector partner, particularly for long-duration projects, while an embedded option could be written in the project agreement granting the transfer of the facility to the private sector partner based on mutually-agreed terms and conditions in the event that the residual facility ends up with positive residual value that is of the nature of a private good. Such an arrangement could lead to a reduction in the output tariff as the government stands to bear the RVR while, at the same time, presenting an incentive for the optimal investment of the private sector partner(s). Second, goverments should give special attention to the selection of appropriate project sizes, which in this study effectively relates to the level of project investment as percent of GDP. In developing countries, particularly, projects too big relative to potential demand and affordability by end-users and/or the government fiscus will have a higher likelihood of failure because of its tendency to restrict public sector policy choices and end-users' demand for cheaper alternatives in the presence of technological advancement. Third, governments seeking to engage in PPPs should ensure that they have the explicit support of the different arms of government as well as the general public in order to avoid future reversal of project agreements that may affect the welfare of the private sector partner in the event of *ex-post* renegotiations.

Intuitively, the huge infrastructure gap being faced globally (which is particularly in the Energy and Transport sectors), works against the sustainable development aims of developing countries. Governments have a huge role to play in this. We conclude that residual ownership risk of PPP infrastructure projects is related to project failures, which impede countries' development efforts and to derive the long-term benefits of infrastructure investments to complement other development efforts. Developing country governments, particularly, seeking to undertake PPPs for development, need to give critical consideration to residual ownership risk to minimise projects failures.

Although our analysis shows a positive impact of the assignment of residual ownership to the government on the survival of infrastructure projects, it is essential to also recognise that government officials may be motivated to assume residual ownership for personal gains. This is consistent with the rich public choice literature. In line with Li and Maskin (2021), we recommend that future research may consider evaluating the complex interactions between the motives and behaviour of government officials and the private sector within the context of the assignment of residual ownership.

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Appendix I

Censoring of the Data

The extant literature (see Jenkins, 2005) identified three main types of censoring, including:

1. Right censoring: this occurs when the study comes to an end without the subject experiencing the event of interest, or when the subject drops out during the study period because something other than the event of interest occurred. Right censoring is regarded as the most common form of censoring.

2. Left censoring: this occurs when the initial time at risk for the subject is unknown. That is, the subject experienced the event prior to the commencement of the study.

3. Interval censoring: this is a combination of both right and left censoring. In this type of censoring, it is known that the event of interest occurred between two time points, but the exact time of occurrence of the event is unknown. For example, if a project is reported as being operational at Period 1 of a panel study, but failed before Period 2, then the failure time is interval censored as it happens between two time periods.

Appendix II

Appendix IIA:

For completeness, we employ two sets of control variables. Our first set depicts the specific characteristics of PPP projects as contained in the PPI dataset, and includes: the *project size* and the *participation of multilateral institution(s) as well as local sponsor(s)* in the project arrangement. The second set of control variables depicts the characteristics of the country where the project is implemented. The reason is based on their tendency to influence the ability of the public sector and/or the end-users to meet their obligations under PPP arrangements or afford the PPP project output, which may culminate in early project failure. Specifically, the variables include Fiscal Control variables (Public Debt Burden and Government revenue as a percentage of GDP); Macroeconomic and Market Control variables (the pricing group being inflation and exchange rates, and the Output group being GDP per capita and Population). The data for this set of variables were directly obtained from the World Bank's World Development Indicators (WDI) and World Governance Indicators (WGI) databases. Political Control variable (the political stability and the absence of violence (PSAV) reported by the World Bank

Project Size

The size of a project is considered to be an endogenous variable, which could make the estimated coefficient binding the relationship between residual facilities ownership and the risk of PPP project failure to be likely biased and not directly interpretable (Nini, 2004). To mitigate this problem of endogeneity, a dummy variable was created for project size through a 2-step process. First, determining the total investment divided by the 4-year average GDP, then creating a 3-way dummy for project size - small ($<34^{th}$ percentile), Medium (between 34^{th} and 63^{rd} percentile) and Large ($>63^{th}$ percentile).

Participation of Multilateral Institutions

The aim here is to check whether or not there is the participation of multilateral institution(s) in the PPP project arrangement. This means that the variable of interest is one of a binary nature with 1 representing the presence of multilateral institution(s) and 0 otherwise. The field 'Multilateral Support' in the PPI dataset makes provision for this kind of assessment.

Participation of Local Sponsors

Similar to multilateral institutions, local sponsors' participation in PPPs is a dichotomous variable with 1 representing the presence of a local sponsor and 0 otherwise. The PPI dataset gives a field for *Sponsors*, which provides information on the name of the sponsors and countries of domicile as well as the percentage equity contribution of the various sponsors. A project could have foreign or local or both foreign and local sponsors. In this study, a local sponsor refers to non-parastatal that is domiciled in the host country of the project. A parastatal being another name for a state-owned enterprise. Since the dataset combines both foreign and local sponsors, the following steps were undertaken to determine whether or not a project has the participation of local sponsor(s):

1. check the country of origin or incorporation of the sponsor. If this country is the same as the host country of the project, then a value of 1 is recorded against the project, indicating the presence of local sponsor, otherwise a value of 0 is recorded.

2. if the country of the sponsor is not available in the 'Sponsors', field, a search is made using the name of the indicated sponsors for the project on Google and other websites, including that of the sponsor, to get information on the sponsor's country of incorporation. Once this determination is made, the appropriate value is then assigned against the project.

Fiscal Control Variables

Following the extant literature, as well as the joint World Bank and International Monetary Fund (IMF) debt sustainability framework for low and middle income countries, public debt burden is captured through stock/solvency and flows/liquidity indicators. The solvency indicator that is often used is the public and publicly guaranteed (PPG) debt as a percentage of nominal GDP (DstockGDP). The World Bank also uses present value (PV) of debt in order to account for the level of concessionality in loans given to especially IDA-only countries. According to the World Bank, Public and publicly-guaranteed external debt comprises long-term external obligations of the public sector, including the national government, political subdivisions (or an agency of either), and autonomous public bodies, and external obligations of private debtors that are guaranteed for repayment by a public entity. For the liquidity indicator, the study uses external debt service payments as a percentage of exports of goods and services (DSerExp).

Macroeconomic and Market Control Variables

The macroeconomic and market control variables are put into two groups:

1. Pricing group - this includes inflation and exchange rates, which are variables that directly affect the pricing of the PPP output. Inflation (Infl.) is measured by consumer price index (CPI), while exchange rate (ExRate) is a measure of a country's currency relative to the United State dollars. The CPI measuring price change from the perspective of the purchaser.

2. The output demand group - This includes GDP per capita (GDPPC) and population (Popn) of the country where the project is implemented.

Political Control Variables

As a way of capturing political instability in countries that are implementing PPPs, the study utilises the variable, political stability and the absence of violence (PSAV). This variable is an index compiled by the World Bank (in the world governance indicator database), which ranks countries in ascending order of better political stability and absence of violence.

Appendix IIB:

Table 7: Main Empirical Results

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
Constant ONE	-4.006***	0.110	-4.231***	0.281	-3.698***	0.318	-3.496***	0.318	-4.836***	0.937
Time in years										
(Spell - 5)	-0.262***	0.027	-0.350***	0.029	-0.356***	0.030	-0.254***	0.037	-0.283***	0.039
(Spell - 5)2̂	0.004.	0.002	0.006**	0.002	0.007**	0.002	0.003	0.003	0.004	0.003
PPP Sub-type (reference = BOT)										
BOO	1.055***	0.135	0.926***	0.233	0.829***	0.233	0.636**	0.234	0.558*	0.242
Project Size (Reference = Large)										
Size_medium			-0.454**	0.175	-0.403*	0.189	-0.318.	0.191	-0.331.	0.190
Size_small			-1.221***	0.244	-1.072***	0.275	-0.969***	0.277	-1.023***	0.283
Interaction with Time										
BOO*(Spell - 5)							1.178***	0.040	1.163***	0.041
Multilateral Institution Participation (reference = no)										
Mult_Part (yes)			-0.071	0.200	-0.128	0.206	-0.151	0.205	-0.196	0.208
Local Sponsor Participation (reference = no)										
L_Spon_Part (yes)			0.091	0.150	-0.030	0.156	-0.018	0.155	-0.081	0.156
Sector (reference = Energy)										
Telecom			2.385***	0.219	2.033***	0.227	1.791***	0.227	1.817***	0.239
Transport			1.357***	0.252	1.056***	0.256	1.099***	0.255	1.102***	0.262
Water & Sewarage			1.505***	0.270	1.264***	0.271	1.242***	0.270	1.231***	0.276
Region (reference = EAP)										
ECA			-0.098	0.250	0.045	0.326	-0.023	0.327	-0.318	0.344
LAC			0.084	0.185	-0.290	0.274	-0.305	0.272	-0.176	0.268
MENA			-1.314**	0.481	-1.146*	0.523	-1.202*	0.524	-1.479**	0.534
SA			-0.655**	0.248	-1.105***	0.302	-1.130***	0.297	-0.398	0.383
SSA			-0.776**	0.273	-1.135***	0.331	-1.086***	0.325	-0.518	0.360
Population										
C_Lpopn					0.004	0.078	-0.009	0.077		
KC_LPopn(-1.44,0.308]									0.520	0.581
KC_LPopn(0.308,2.06]									0.193	0.580
KC_LPopn(2.06,3.81]									0.000	0.617

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Table 8: Main Empirical Results (Cont'd)

Variable	Model 1 Parameter Estimate	Model 1 Robust Std. Error	Model 2 Parameter Estimate	Model 2 Robust Std. Error	Model 3 Parameter Estimate	Model 3 Robust Std. Error	Model 4 Parameter Estimate	Model 4 Robust Std. Error	Model 5 Parameter Estimate	Model 5 Robust Std. Error
GDP per capita										
C_LGDPPC					-0.069	0.157	-0.111	0.154		
KC_LGDPPC(-1.1,-0.0366]									0.240	0.415
KC_LGDPPC(-0.0366,1.03]									0.440	0.451
KC_LGDPPC(1.03,2.1]									-0.076	0.491
Debt Service Payment to Export of Good and Services										
C_LDSerExP					1.086***	0.247	1.170***	0.244		
KC_LDSerExP(-0.08,0.371]									0.148	0.183
KC_LDSerExP(0.371,0.821]									0.336	0.273
KC_LDSerExP(0.821,1.27]									1.441***	0.355
Debt Stock to GDP										
C_LDstockGDP					0.065	0.237	0.012	0.233		
KC_LDstockGDP(-0.597,0.228]									0.125	0.192
KC_LDstockGDP(0.228,1.05]									-0.105	0.348
KC_LDstockGDP(1.05,1.88]									-0.583	0.736
Government Revenue to GDP										
C_LRev_GDP					-0.598*	0.283	-0.579*	0.281		
KC_LRev_GDP(-0.473,0.0273]									-0.146	0.227
KC_LRev_GDP(0.0273,0.527]									0.220	0.276
KC_LRev_GDP(0.527,1.03]									-2.400*	1.063
Inflation										
C_Linfl					0.022*	0.010	0.023*	0.010		
KC_Infl(-3.97,4.78]									-0.241	0.178
KC_Infl(4.78,13.5]									1.015***	0.256
KC_infl(13.5,22.3]									0.686*	0.289
Exchange Rate										
C_LEXRate					-0.001	0.033	-0.004	0.033		
KC_LEXRate(-2.18,0.888]									0.834**	0.285
KC_LEXRate(0.888,3.95]									0.032	0.344
KC_LEXRate(3.95,7.03]									0.336	0.374

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Table 9: Main Empirical Results (Cont'd)

Variable	Model 1 Parameter Estimate	Model 1 Robust Std. Error	Model 2 Parameter Estimate	Model 2 Robust Std. Error	Model 3 Parameter Estimate	Model 3 Robust Std. Error	Model 4 Parameter Estimate	Model 4 Robust Std. Error	Model 5 Parameter Estimate	Model 5 Robust Std. Error
Political Stability and Absence of Violence										
PV.EST					0.083	0.127	0.159	0.128		
K_PV.EST(-1.89,-0.79]									0.311	0.364
K_PV.EST(-0.79,0.31]									0.024	0.385
K_PV.EST(0.31,1.41]									0.020	0.488
Goodness-of-fit										
Deviance	2335.8		2109.9		2056.3		2032.5		1984.9	
No. of Parameters	4		16		24		25		41	
AIC	2343.8		2141.9		2104.3		2082.5		2066.9	
Diff. in Deviance Test (Chi-square test)		*225.9****		*53.6****		*23.8****		*47.6****		

Notes:
1) '***', '**', '*' and '.' denote significant estimate at 0.1%, 1%, 5% and 10% respectively
2) The models presented here are all nested models. Model 1 has PPP Sub-type as the only explanatory variables; Model 2 added project characteristics; Model 3 added characteristics; Model 4 added PPP Subtype interaction with time; and Model 5 investigates for non-linearity in Model 4.
3) The various models are tested using difference in deviance test and the result show that Model 5 is superior to the other models. The model also has the lowest deviance and AIC statistics.
4) The standard errors are robust, computed using the Sandwich Package in R Programming.
5) The prefix C in front of the variable means that the variable is centered from the median while KC means the variable is both centered and categorised.

Appendix IIC:

Robustness checks

We note that BOT to BOO projects have similar structures, except mainly for the ownership of the residual facility - they both bundle project construction with operation under a concession agreement that stipulates the period over which the public sector is obligated to assure the recuperation of the investment of a private sector partner. However, our results may be model dependent (see Ho *et al.*, 2007). Therefore, to check the robustness of our results, we utilise the Propensity Score Matching (PSM) approach (see among others, Abadie and Imbens (2006)). Our analysis for creating a matched sample is conducted using the*MatchIt* package in the R-Programming language (Ho *et al.*, 2011). Our results using the matching approach are qualitatively similar to those reported in the paper. Briefly, using the matched dataset, we find that the odds for BOO projects experiencing the event of failure are about three times ($e^{1.0489} = 2.854$) that of BOT projects, corroborating results from *Model 2*. We also find both size and sector variables to be highly significant, with small size projects and projects in the Energy sector having comparatively lower risk of failure.

As a further robustness test, we consider two additional PPI Sub-types. The first PPI sub-type is *Rehabilitate, Operate and Transfer* (ROT), under which the public sector owns both the initial as well as residual facilities of the project, while the second is *Merchant* (Mct), which captures total facilities ownership by the private sector. The latter is usually considered as a pure private sector venture where the private sector partner assumes nearly all the risks and rewards associated with the project. The aim, therefore, is to see whether the risk of failure is lower for both ROT and BOT projects compared to BOO and Mct. A total of 492 ROT projects and 230 Mct projects were used in the analysis. Briefly, our results from the Kaplan-Meier non-parametric discrete-time survival function, indicate that both PPI Sub-types that allocate ownership of residual facilities to the public sector (BOT and ROT), have higher survival probabilities than those for which the private sector retains residual ownership (BOO and Mct). The restricted mean shown in Table 10 indicates that ROT and BOT projects have a similar restricted mean year of survival of approximately 26 years, while BOO and Mct have approximately 22 and 20 years of survival respectively.

Table 10: Restricted Mean of the Four PPI Sub-types (based on Propensity Score Matched sample)

PPI Sub-types	Number of Observations	*rmean	*se(rmean)
Build, Own and Operate (BOO)	629	21.6	0.701
Build, Operate and Transfer (BOT)	1370	25.5	0.175
Merchant (Mct)	230	19.7	0.694
Rehabilitate, Operate and Transfer (ROT)	492	25.2	0.288

* restricted mean with upper limit = 27

These further confirm that the conferment of residual facilities ownership to the public sector reduces the risk of PPP project failure.

SUPPLEMENTARY APPENDIX

Figure 6: Kaplan-Meier Result for Regional Grouping

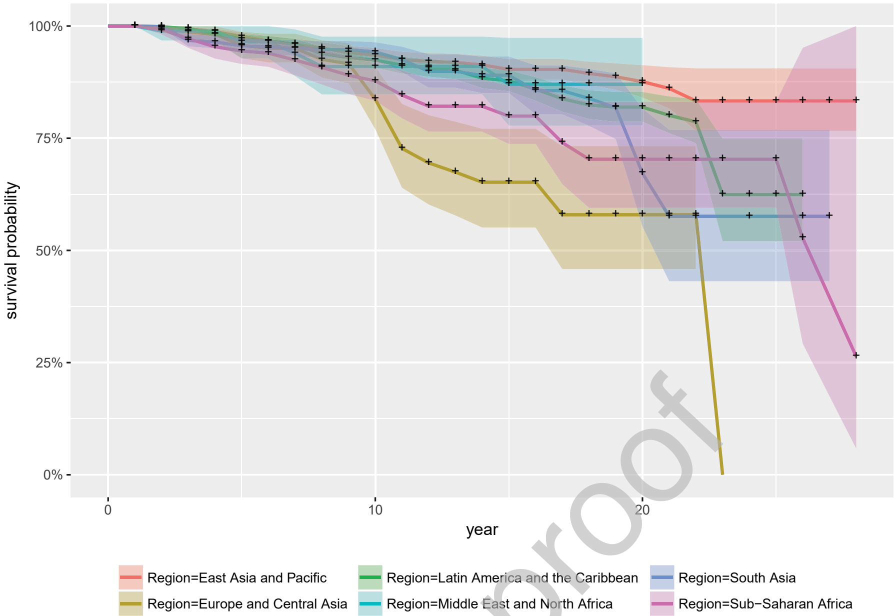
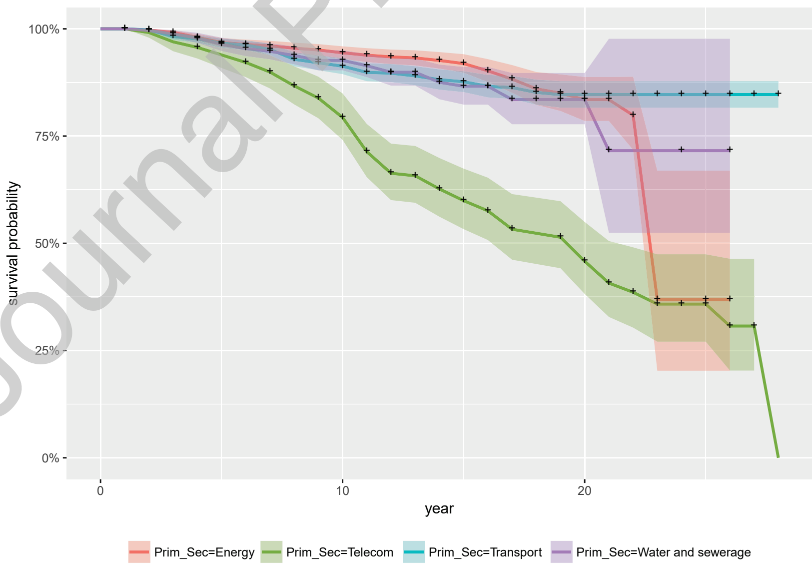


Figure 7: Kaplan Meier Result for Primary Sector Grouping



Declarations of Competing Interest

None.